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PCT/GB2005/000078

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1. Your reference — QIP/P7336

2. Patent application number *(The Patent Office will fill in this part)* — 0401053.4

19JAN04 E866338-1 D02776
P01/7700 0.00-0401053.4 ACCOUNT CHA

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

QINETIQ LIMITED

Registered Office 85 Buckingham Gate
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United Kingdom

Patents ADP number *(if you know it)* — 08527376002

If the applicant is a corporate body, give the country/state of its incorporation — GB

4. Title of the invention — Improvements in and relating to accelerometers

5. Name of your agent *(if you have one)* — Ian Michael Johnson

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

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Patents ADP number *(if you know it)* — 08183873001

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Country	Piority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number or earlier application	Date of filing *(day / month / year)*

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Description	4
Claim(*s*)	1
Abstract	1
Drawing(*s*)	2

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Priority documents	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I / We request the grant of a patent on the basis of this application.

Signature — I.M. Johnson, Agent for the Applicant — Date: 16.01.2004

12. Name and daytime telephone number of person to contact in the United Kingdom — Mrs Linda Bruckshaw 01252 392722

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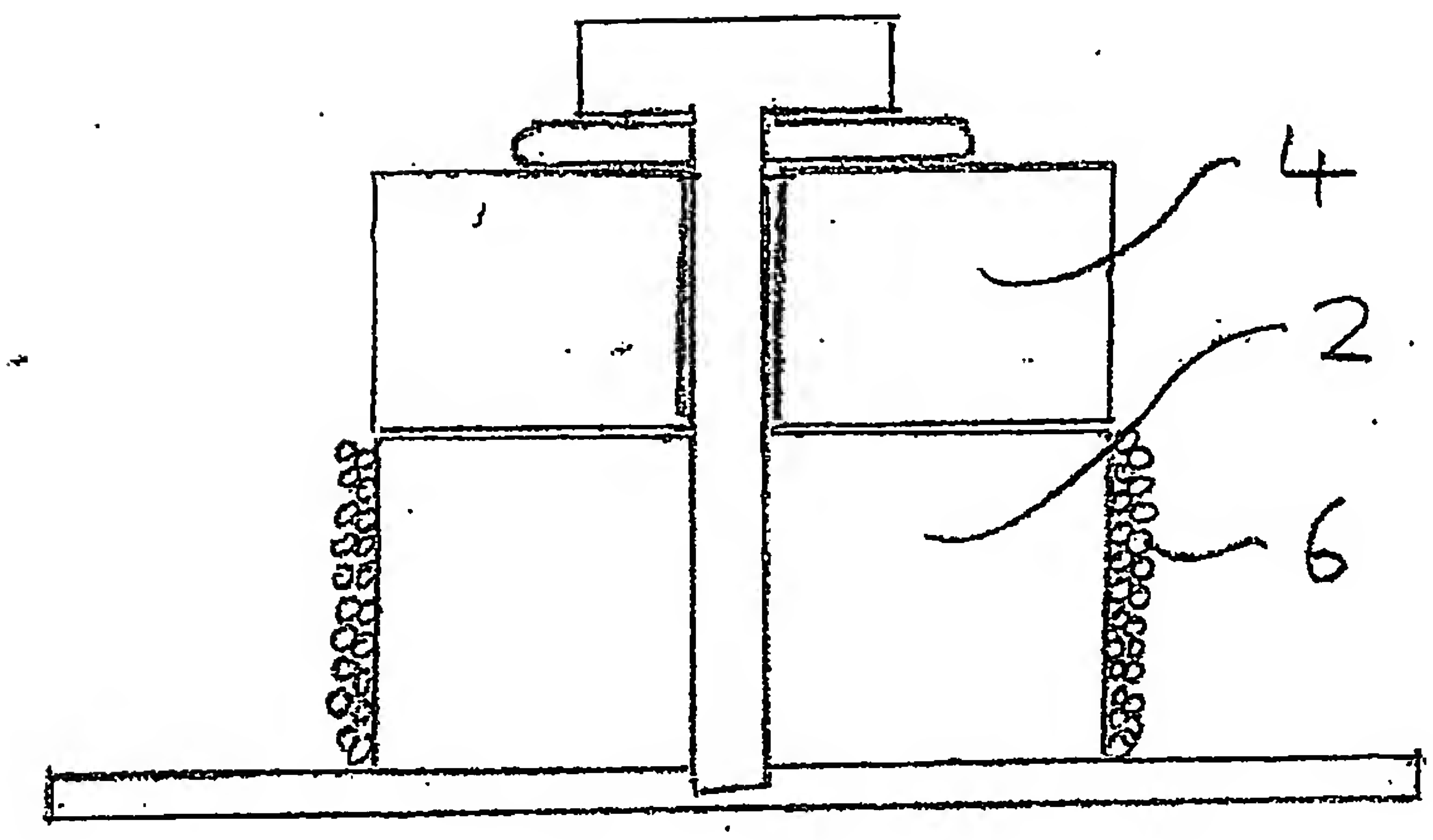

PRIOR ART figure 1

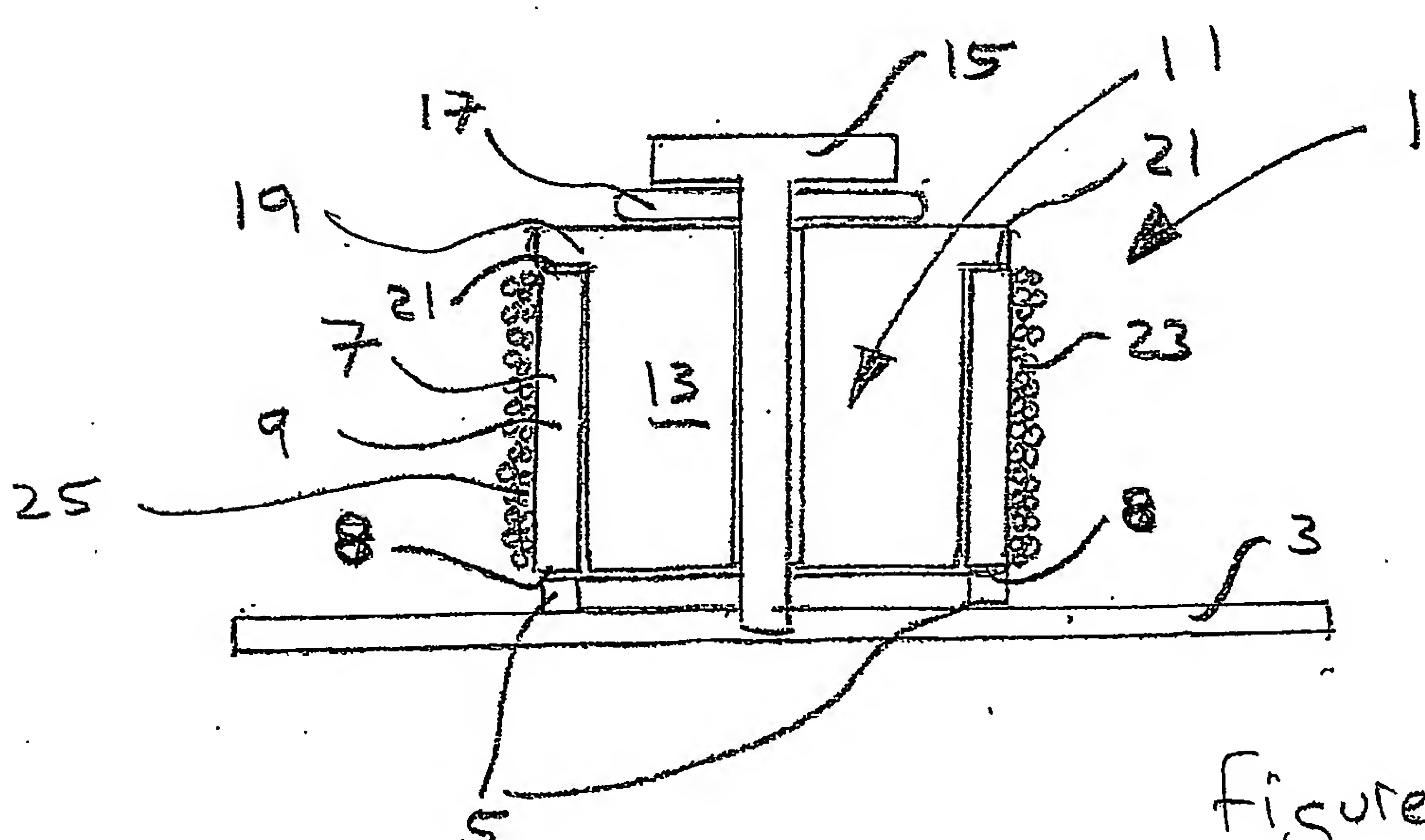

figure 2

2/2

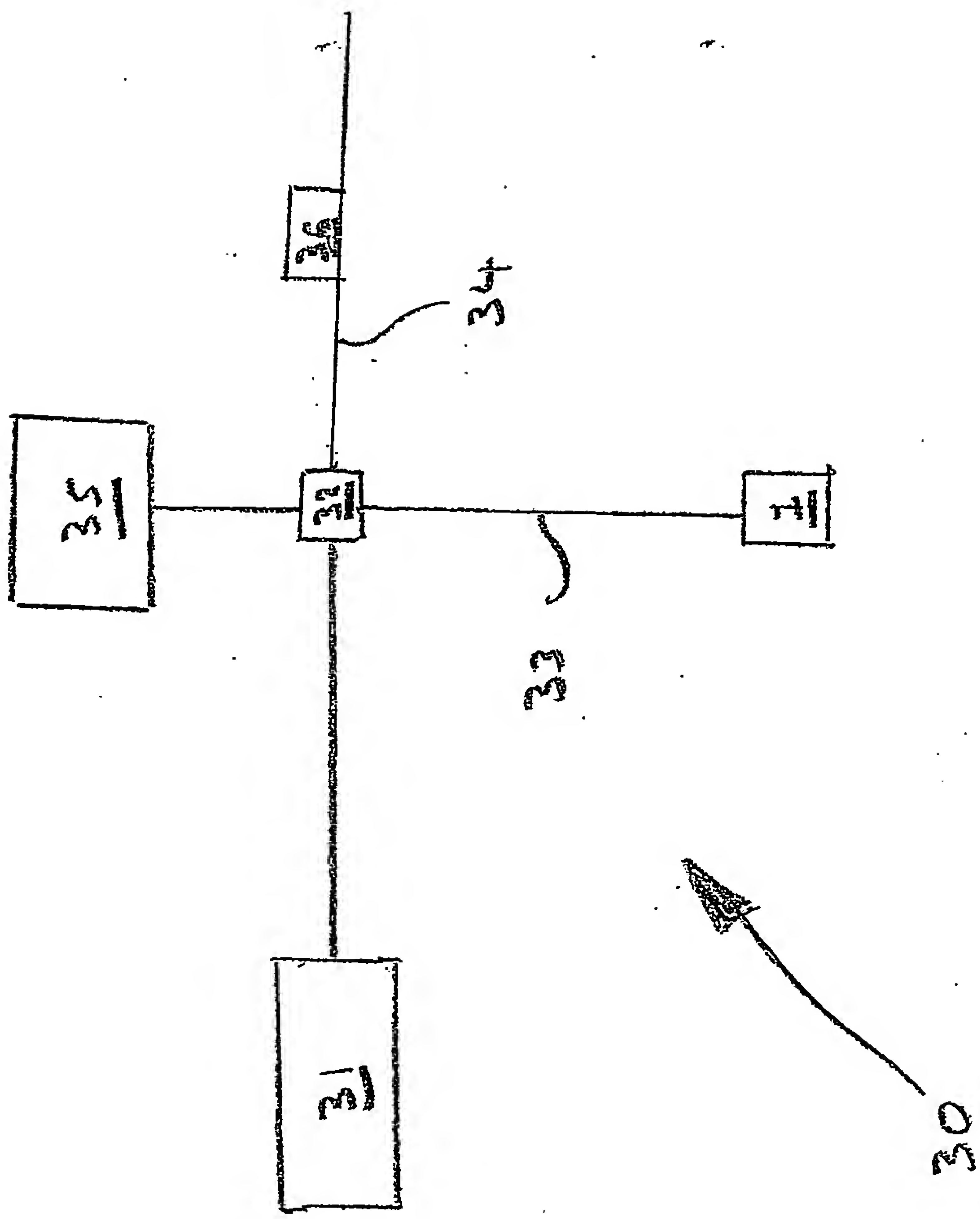

Figure 3

Improvements in and relating to accelerometers

The present invention relates to accelerometers and particularly fibre optic accelerometers for use in interferometers.

The need to monitor extremely low levels of vibration in areas such as security, seismic survey and condition monitoring of machinery and such like has spurred the development of ever more sensitive accelerometers. Fibre optic technology has been applied to this particular field in the form of fibre-optic accelerometers based on interferometric techniques. The compliant cylinder approach to the design of a fibre-optic accelerometer is particularly effective when incorporated in such an interferometer. In one known approach a seismic mass is held in place by two compliant cylinders and around the circumference of each cylinder there being wound a single mode optical fibre, which form the arms of an interferometer. In another approach, a single compliant cylinder 2 loaded with a seismic mass 4 as shown in Figure 1 is wound circumferentially with an optical fibre 6.

Whilst the abovementioned approaches have found acceptance, there remains a need to increase yet further the sensitivity of the accelerometer beyond that currently achievable and in particular to do so without any increase in component size. The present invention seeks to improve the sensitivity of a fibre wound compliant cylinder accelerometer whilst simultaneously seeking to avoid additional cost and complexity of construction.

Thus, according to one aspect of the invention, there is provided a fibre optic accelerometer comprising a seismic mass coaxially constrained within a cylinder of compliant material, the cylinder being circumferentially wound with optical fibre.

Preferably, the accelerometer is mounted on a plate which may or may not in practice be an integral part of a platform or structure on which the accelerometer is deployed. Conveniently, a tension member retains the accelerometer against the plate. The tension member may be a bolt or other well known tensioning component. Equally, the tension member may be provided by an enclosure or can acting on the accelerometer. Advantageously, the tension member acts on the accelerometer via a compliant material washer whilst a rigid support ring is interposed between the plate and the cylinder to ensure that relative movement is possible.

It will be recognised that a suitable compliant material for the cylinder will have a relatively low Young's modulus but with a Poisson's ratio close to 0.5, such that the stiffness of the accelerometer arises more from the circumferential winding than the cylinder itself. Thus for a particular force acting on the cylinder, the greater the strain induced in the fibre and hence sensitivity of the accelerometer. Furthermore, by constraining the seismic mass coaxially within the cylinder, the tendency present in prior art devices for the cylinder to buckle or otherwise respond unfavourably to acceleration orthogonal to the cylinder axis is limited. Advantageously, this leads to improved performance of devices incorporating the accelerometer in which sensitivity in a single axis is paramount.

It will be further recognised that by reducing the wall thickness of the cylinder the sensitivity of the accelerometer can be still further increased. Prior art devices have hitherto sought to increase sensitivity either by increasing the seismic mass and/or the height of the cylinder supporting the seismic mass. Both approaches whilst increasing the desired sensitivity may also have the problem of increased sensitivity to orthogonal acceleration mentioned above and will result in an increased accelerometer size. With the trend towards miniaturisation of components, the present invention lends itself to providing improved performance to prior art devices for a given volume and mass.

In order to assist in understanding the invention, a particular embodiment thereof will now be described, by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional side view of a prior art fibre optic accelerometer;
Figure 2 is a cross-sectional side view of a fibre optic accelerometer in accordance with the present invention; and
Figure 3 is a schematic view of an optical interferometer incorporating an accelerometer of Figure 2.

The fibre optic accelerometer 1 is mounted on a base plate 3 via a rigid support ring 5. The ring 5 can be formed either as a relief in the base plate 3 or perhaps more conveniently, it can be provided as a separate component, thereby allowing differing sizes of accelerometer 1 to be mounted on the base plate 3. The base plate 3 itself is produced from a rigid material, typically steel although other metals and composites may suggest themselves to those skilled in the art. Furthermore, it should be understood that

references throughout the description to a base plate are also intended to encompass the direct mounting of the accelerometer to a platform or other structure.

The support ring 5 is in contact with a first end face of a compliant cylindrical member 7. The cylindrical member has relatively thin wall 9 and a coaxial void 11 such that a seismic mass 13 may be received therein. The compliant cylindrical member 7 is formed from a material having a relatively low Young's modulus such that it is capable of deformation under low levels of loading in an axial direction. Typically, a rubber or rubber like material may be utilised. Such materials also have a Poisson ratio approaching a maximum of 0.5 meaning that an efficient transfer of axial deformation into circumferential deformation in the cylinder 7 can take place.

The seismic mass 13 is held by a tension member in the form of a bolt 15 secured to the base plate 3. Whilst in a non-illustrated embodiment the tension member is provided by an enclosure or can, other forms of tension member will be readily apparent to those skilled in the art. The bolt 15 bears on the seismic mass 13 via an elastomeric member which is most easily provided by a pad 17 of rubber of rubber-like material. The seismic mass 13 itself is so shaped that a generally disc shaped portion 19 bears on a second end face 21 of the compliant cylindrical member 7. In use, acceleration forces acting on the seismic mass 13 bring about a displacement which is coupled to the cylindrical member 7. Without the tension member 15, there would be no coupling of displacement to the cylindrical member 7 where the sense of acceleration is such as to urge the disc shaped portion 19 out of contact with the second end face 21. In effect, the tension member 15 preloads the cylindrical member 7 with an initial displacement. Depending on the range of acceleration expected, the preload may be varied by altering the level of tension provided by the tension member 15.

The cylindrical member 7 is wound with a length of optical fibre 23. The winding may be single or multi layered. The optical fibre 23 is wound about an external surface 25 of the cylinder 7 and may be secured mechanically, adhesively or through another or combination of techniques to ensure that as completely as possible the possibility of slippage between the fibre 23 and the cylinder surface 25 is minimised.

It will be appreciated that the optical fibre 23 constrains the cylindrical member 7 against circumferential deformation thus generating a level of hoop stress in the fibre 23. This hoop stress alters the physical characteristics of the optical fibre 23 such that by incorporating the accelerometer in one arm of an optical interferometer (Figure 3) a

stress value proportional to the acceleration acting on the accelerometer 1 can be determined.

Figure 3 shows the accelerometer 1 as an element in an optical interferometer 30 used to determine acceleration. In this embodiment there is provided a source of laser light 31 a coupler 32, coupling two arms 33,34 of fibre optic cable and an output to a display 35. One of the arms 33 contains the accelerometer 1 whilst the other arm 34 includes a polarisation corrector 36. The operation of such an interferometer 30 will be apparent to those skilled in that art just as those skilled in the art will recognise that this interferometer is purely illustrative and that the accelerometer of the invention may be deployed in a host of interferometer applications.

Whilst those skilled in the art will recognise the improvements in resistance to off-axis acceleration effects conferred by the above described embodiment, further steps may be taken to minimise the detrimental effect of such inputs. Accordingly, a shim may be added between the tension member and the cylinder to resist out of axis inputs whilst maintaining on-axis sensitivity.

Claims

1. A fibre optic accelerometer comprising a seismic mass coaxially constrained within a cylinder of compliant material, the cylinder being circumferentially wound with optical fibre.

2. An accelerometer as claimed in Claim 1, wherein the seismic mass is surmounted with a disc shaped portion.

3. An accelerometer as claimed in Claim 1 or Claim 2, wherein the seismic mass is secured by a tension member to a base plate.

4. An accelerometer as claimed in Claim 3, wherein a spacer is provided between the cylinder and the base plate.

5. An accelerometer as claimed in Claim 4, wherein the spacer is integral with the base plate.

6. An accelerometer as claimed in any preceding Claim, wherein the optical fibre is wound in a single layer.

7. An accelerometer as claimed in any preceding Claim, wherein the base plate is integral with a platform or structure.

8. A fibre optic accelerometer substantially as described herein with reference to Figure 2 of the accompanying drawings.

9. A optical interferometer substantially as described herein with reference to Figure 3 of the accompanying drawings.

Abstract

Improvements in and relating to accelerometers

A fibre optic accelerometer (1) particularly intended for use with an interferometer (30) is described. The accelerometer (1) utilises the compliant cylinder approach but through providing the seismic mass (13) at the core of the cylinder (7), this results in improved sensitivity and rejection of out of axis inputs.

(Figure 2)

PATENT COOPERATION TREATY

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PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

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A4 Building, Room G016
Ively Road, Farnborough
Hampshire GU14 0LX
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Date of mailing *(day/month/year)* 14 March 2005 (14.03.2005)	
Applicant's or agent's file reference IP/P7336/WOD	**IMPORTANT NOTIFICATION**
International application No. PCT/GB05/000078	International filing date *(day/month/year)* 12 January 2005 (12.01.2005)
International publication date *(day/month/year)*	Priority date *(day/month/year)* 17 January 2004 (17.01.2004)
Applicant QINETIQ LIMITED et al	

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Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
17 January 2004 (17.01.2004)	0401053.4	GB	09 February 2005 (09.02.2005)

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